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Abstract

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John R. Roggenkamp

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A CLINICAL COMPARISON OF THE BURTON I-TRAC REFRACTOR WITH A STANDARD REFRACTOR

By

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A thesis submitted to the faculty of the
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Adviser:

John R. Roggenkamp, O.D.

BIOGRAPHY

John Barringer practiced as a Licensed Optician in Reno, Nevada before returning to school to pursue the Doctor of Optometry degree. Received an Associate of Science in Ophthalmic Dispensing Technology from Pima Community College in Tucson, Arizona in 1975. Attended the University of Nevada-Reno majoring in Biology from 1982 until 1985 and received Bachelor of Science in Visual Science from Pacific University in 1987. Received the Doctor of Optometry in May, 1989.

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ABSTRACT

A new device for performing the Jackson Cross Cylinder test for astigmatism is compared against the traditional flip cylinder, or "J.C.C.", technique. The device, a component of the I-TRAC 8000 Refractor from R.H. Burton Company, uses an electronically controlled, microprocessor based, rotating cross cylinder. The instrument also features a digital display that reads out axis to single degree accuracy. As claimed by the manufacturer, this combination should allow for easier, faster determination of cylinder power and axis, with greater accuracy.

This study compares subjective refraction results determined with a conventional flip cross-cylinder, as mounted on a Reichert Ultramatic Rx Master Phoroptor, against the subjective refraction determined with the rotating cross-cylinder found on the Burton I-TRAC Refractor. Refractions were performed on 40 volunteer subjects ranging in age from 21 to 56 and excluded individuals exhibiting any ocular pathology or binocular difficulties.

The cylinder power findings from the paired refractions showed a relatively poor correlation (R = .846) when compared to the very high correlations found between the spherical (R = .995) and spherical equivalent (R = .995) powers. Comparisons between means of the refractive findings did not show significant differences between the I-TRAC Refractor and the Ultramatic Phoropter. Variations of axis from each pair of refractions did not vary significantly, nor did the number of presentations of the cross cylinder. Questionnaires indicated the subjects were generally neutral regarding testing differences between the two instruments, however a majority (45%) rated their overall reaction to the new instrument as positive.

ACKNOWLEDGMENTS

I would like to thank Dr. Jack Roggenkamp for his help and advice on this project. Thanks also to Bill Woodman for his help in interpreting the statistical results. Special thanks to R.H. Burton Company for their generous loan of the I-TRAC refractor to the Pacific University Family Vision Center.

INTRODUCTION

The Jackson cross cylinder lens is a well known device used for refining the power and axis of astigmatic corrections. Its components include a plus cylinder and a minus cylinder of equal powers, with axes placed at right angles to each other. This combination results in a spherical equivalent power of plano.(1) When placed in combination with a correcting cylinder lens, the cross cylinder lens can be used to increase or decrease the Interval of Sturm without changing the equivalent spherical power. The size of the circle of least confusion will also be increased or decreased, thus allowing for a subjective refinement of the astigmatic lens correction (see Figure 1). Changes are made to the axis and power of the correcting cylinder based on subjective responses to the cross cylinder presentations until the patient can no longer discern a difference between the choices.(2)

Insert Figure 1 about here.

Currently, the most prevalent design for the cross cylinder mechanism has the lens mounted in a cell that provides for placement of it in front of the refractor's lens aperture. The lens cell can then be rotated into either power refinement (axes coincident with correcting lens axis), or axis refinement (axes 45 degrees from correcting lens axis) position. The lens is mounted within this cell on an axle that coincides with the meridian of the axis refinement position. The axle is fitted with a roll knob that permits rapid "flipping" of the cross cylinder lens. When flipped, the lens makes a 90 degree change in position with a corresponding shift in the astigmatic interval. On many refractors, such as the Reichert Phoroptor, the cross cylinder lens position and the correcting cylinder axis orientation are synchronized by means of a system of gears and are simultaneously rotated by the refractor's axis control knob. Consequently, correct alignment between the cross cylinder lens and the correcting lens is automatically maintained during the cylinder refinement sequence.(3)

The R.H. Burton Company, of Grove City, Ohio, has recently developed an innovative variation of the Jackson Cross Cylinder mechanism. Found on the company's new model I-TRAC 8000 Electronic Refractor, it features an electronically controlled, microprocessor based system that provides for a rapid rotation of the cross cylinder lens via a remote control selector. An integral part of the mechanism is a digital display of cylinder axis that reads out in single degree increments. The refractor also includes internal illumination for sphere power, cylinder power and corneal sighting apertures.

As opposed to more traditional designs, the Burton I-TRAC cross cylinder lens makes a rapid rotary motion which is initiated by means of a remotely held switch. The mechanism uses an optical encoder mounted under the axis control knob to provide position (axis orientation) information to a photodetector which, in turn, relays it to the microprocessor. Another encoder and photodetector within the cross cylinder bezel also feeds positional data to the microprocessor. This information is compared, and if a difference in angles is detected, the microprocessor activates a motor worm drive that will turn the cross cylinder lens so as to match the axis of the correcting cylinder. The microprocessor also reports the cylinder lens axis to L.E.D. indicators on the face of the refractor with one degree accuracy.(4)

The I-TRAC system consists of the refractor, a power unit, a remote control unit, and all cords necessary to connect the components. Set up and operation of the system is straight-forward and can be accomplished quickly.

The refractor resembles the Reichert Phoroptor in its layout and operating controls except for the cross cylinder mechanism and the lighted displays which are unique to the I-TRAC system (see figure 2).

Insert Figure 2 about here.

The power unit is mounted to the instrument stand and provides electrical energy to the system. It has two on-off switches, one for system power and one controlling window illumination. It also receives connections from the refractor and from the remote control device.

The remote control unit also has a power on/off switch along with two sets of control buttons, one set each for the left and right lens banks (see figure 3). The upper button initiates a 90 degree rotation of the cross cylinder (equivalent to "flipping" a conventional J.C.C.) and activates a pair of illuminated arrows above the axis control knob, each arrow indicating a corresponding shift of the cross cylinder lens orientation.

Insert Figure 3 about here.

The lower button rotates the test lens 45 degrees to allow shifting between the axis and power modes. It also activates an L.E.D. display below each axis indicator to show which mode has been selected.

Operation of the device is straight forward and simple to learn. When ready to begin the cylinder refinement sequence, the operator places the rotary lens in position and selects the appropriate mode, either power or axis, with the lower of the two selector buttons. Then, using the upper button of the remote control, alternating choices are presented to the patient. If there is a preference for one position over the other, the arrow that is illuminated in the preferred position indicates the direction to rotate the correcting cylinder axis knob, or to change the cylinder power, before giving the next cross cylinder presentation. Each sequence is continued until the patient perceives no difference between the two choices (5).

The manufacturer of this system makes several claims regarding the efficacy of this design. First, since the coordination between the cross cylinder lens and the correcting cylinder axis is maintained by the microprocessor and is motor driven, gear backlash is eliminated to provide a more accurate axis determination. Secondly, because of the rotating cross cylinder lens, the patient has a continuous view of the target. The manufacturer claims that this allows for an instantaneous comparison of the cross cylinder choices and eliminates the uncertainty some patients experience with conventional, "flipped", cross cylinder lenses. In addition to these, several other advantages have been reported regarding the accuracy, efficiency and convenience of the Burton I-TRAC Refractor (see Appendix A).

This clinical study was designed to see if any objective or subjective differences could be measured in support of the manufacturer's claims for the I-TRAC refractor by comparing it to a conventional refractor with a synchronized cross cylinder lens.

METHODS

In order to test the claims regarding the speed, accuracy and ease of response to the I-TRAC Refractor, it was decided to compare refractive results taken with it to those measured on a Reichert Ultramatic Rx Master Phoroptor, a well known instrument that represents the lenses and features used by most practicioners. Assessing speed of testing was a more difficult challenge. To that end, an assumption was made that if the new device was indeed quicker and easier to respond to, then fewer presentations of the cross cylinder lens might be needed in order to reach an endpoint. To this end, it was decided that counting the number of "flips", or presentations, of the cross cylinder lens for each refraction would give a valid comparison for this aspect. Finally, to assess the subjective qualities of viewing through, and responding to, the rotating cross cylinder, a questionnaire was submitted to each subject following the two refractions (see Appendix B). An opportunity was also given each subject to make any positive or negative comments they had regarding either refracting instrument.

Forty volunteer subjects between the ages of 21 and 56, who were self-screened for normal binocular vision and had no active ocular pathology, were given a binocular refraction on each of the two instruments. The I-TRAC 8000 Electronic Refractor, identified to the subjects as the "electronic" instrument, is manufactured by the R.H. Burton Company of Grove City, Ohio and the other, identified as the "standard" instrument, an Ultramatic Rx Master Phoroptor from Reichert Ophthalmic Instruments of Buffalo, New York. All refractions were performed by a fourth year Intern at the Pacific

University Family Vision Center in Forest Grove, Oregon. Adjacent examination rooms were used, and were matched for target viewing distance and room illumination. To help eliminate instrument bias, half of the subjects were refracted first with the Burton instrument while the rest were started on the Reichert instrument. The second refraction immediately followed the first.

Static retinoscopy established the baseline for each pair of refractions, followed by a standardized test sequence performed with each instrument. Beginning monocularly, maximum plus to 20/20 was established as preset for the cross cylinder test. The J.C.C. sequence was also performed monocularly with axis refinement preceding power refinement except when no cylinder was present from retinoscopy. In such cases, a power search sequence was done in the horizontal, vertical and oblique meridians. If cylinder was accepted in any meridian, then axis refinement was performed. All cross cylinder choices for each sequence were numbered consecutively, eg. 1 or 2, 3 or 4, etc. and continued until no difference, or first reversal, was noted. The final value was then recorded as "number of flips". After cylinder correction was established for each eye, a dissociated 20/40 accommodative balance was confirmed. Following this, plus was reduced binocularly until any letter on the 20/20 line could be recognized. The final endpoint was established by adding an additional -0.50D. binocularly. Refractive results, monocular acuities and the number of presentations of the cross cylinder choices were then recorded for each eye. Finally, a questionnaire was presented to each subject to assess their subjective responses to the electronic refractor.

RESULTS

In order to compare findings between refractors, data were broken down into several catagories. Refractive findings for all eyes (n=80) were distributed into sphere power, spherical equivalent power and cylinder power classifications with a mean value from each catagory calculated to represent each instrument. Additionally, a mean value was calculated for number of flips of the cross-cylinder lens for both axis and power refinement sequences from each refractor (see Table 1). The means from all five catagories were then compared. Endpoint acuity for all eyes was 20/20.

Insert Table 1 about here.

Figure 4 shows a scatterplot of the sphere powers obtained with the I-TRAC and Ultramatic refractors. The mean value for the I-TRAC was -0.981 diopters and the mean for the standard refractor was -0.931 diopters. The difference of 0.05 diopters was not found to be significant at the 0.001 level using the related measures t-test. Simple linear regression gave a coefficient of 0.995 indicating a high correlation between the two refractors for individual eyes.

Insert Figure 4 about here.

The scatterplot in Figure 5 represents the spherical equivalent power from each refracting instrument. Again, a high correlation (R = 0.995) is found between the two instruments. The related measures t-test found no difference between the means (-1.282 for the

I-TRAC and -1.206 for the Ultramatic) at the 0.001 significance level.

Insert Figure 5 about here.

Figure 6 shows the scatterplot comparing the cylinder power findings from each instrument. Linear regression analysis of these data results in a correlation coefficient of only 0.846 indicating that, for cylinder power, the two instruments were not as well correlated between individual eyes as they were for sphere and equivalent sphere powers. However, when tested at the 0.001 level by the related measures t-test, the mean for the I-TRAC refractor (-0.597 diopters) was not found to be significantly different from that of the Ultramatic Phoropter (-0.531 diopters).

Insert Figure 6 about here.

The average number of flips of the cross cylinder lens to refine axis orientation for the I-TRAC refractor were 8.9 compared to 8.1 for the Ultramatic Phoropter. Again, using a related measures t-test, no significant difference was found. The difference between the two instruments for mean number of flips necessary to reach the power refinement endpoint was 0.225 (7.05 for the I-TRAC vs. 6.82 for the Ultramatic). The related measures t-test showed than these means were not significantly different, either.

Comparision of axis variations between each instrument does not lend it self well to statistical analysis. For instance, the clinical difference of 2 degrees between an axis set at 179 degrees to one oriented at 001 degrees would, logically, be considered quite small. However, the numerical difference of 178 degrees would appear statistically to be quite significant. Similar studies by other investigators (2,6) have shown that a frequency histogram is an acceptable method to analyze the magnitude and variation of axial differences when making such comparisons.

Figure 7 shows that 52.3% of the paired refractions had a difference of 10 degrees or less, and that 76.9% had differences of 20 degrees or less. Except for two eyes, the remaining pairs (23.1%) with axis differences greater than 20 degrees were associated with cylinder powers of -0.50 diopters, or less. These two exceptions also had significant variations in cylinder power between each refraction, perhaps indicating a very low sensitivity to astigmatic changes in these individuals. Considering the low cylinder powers involved, the variations found in this study should be considered to be within clinically tolerable limits for either instrument.

Insert Figure 7 about here.

When asked to subjectively compare the astigmatism tests performed with each instrument, 16 individuals (40%) felt there was no difference between the two refractors, while 30% (12 subjects) felt that the test was easier with the I-TRAC refractor. One person (2.5% of the total) felt that the I-TRAC astigmatism test was very easy by comparison, however 27.5% (11 individuals) felt that the test was harder through the Burton instrument. No subjects reported it to be very much harder.

Subjects were then asked how the rotating cross cylinder's ability to present a continuous view of the target may have affected the astigmatism test. 55% said it made no difference, 15% felt it made the test more difficult and one subject (2.5%) responded that it made the test very difficult. Only 11 subjects (27.5%) felt that it made the test easy, and no subject reported that it made the test very easy.

Question #3 asked subjects to compare their confidence in the final lens selection from the "electronic" refractor to that obtained with the "standard" instrument. 57.5% reported that it was the same, while 12.5% had greater confidence in the I-TRAC results. However, 30% (12 subjects) had lower confidence in the final lens result obtained with the "electronic" instrument.

The subjects were then asked their opinion as to which instrument seemed most accurate. 60% reported no difference while 35% felt the "standard" refractor was. Only 5% (2 subjects) felt that the "electronic" refractor was the more accurate of the two.

When questioned about which instrument was perceived as being fastest, 65% of the subjects felt that the I-TRAC refractor was. 27.5% of the subjects reported no difference, and only 3 subjects (7.5%) thought that the Ultramatic Phoropter was the quickest.

The subjects were then asked for their overall reaction the the "electronic" instrument. One individual (2.5%) responded very positively to it, while 18 subjects (45%) recorded a positive reaction. 15 (37.5%) of the subjects were neutral and 6 subjects (15%) responded negatively to the "electronic" instrument. No one reported a very negative response regarding this device.

Finally, the subjects were asked which instrument they would prefer to be examined with if they were offered the choice. 40%

responded that they had no preference, 42.5% would choose the "standard" refractor while only 17.5% would prefer the "electronic" instrument.

CONCLUSIONS

This study found no statistically significant differences between refractive data measured with a Burton I-TRAC Refractor when compared to a Reichert Ultramatic Rx Master Phoropter. Mean differences between sphere power, cylinder power and spherical equivalent power were all on the order of 1/16 of a diopter. The only notable difference was in the correlation between cylinder power measurements for the paired refractions, which was relatively low in comparison to the very high correlations found between sphere and spherical equivalent powers. No evidence was uncovered that would indicate that the I-TRAC Refractor was more, or less, accurate than the other instrument.

Responses from a majority of the subjects would indicate that the I-TRAC Refractor was perceived as being subjectively faster than the standard refractor. However, an objective comparison for speed of testing based upon the number of cross cylinder presentations showed that both instruments were statistically equal.

When asked to assess the ease of testing with a rotating cross cylinder, most individuals were neutral in their preference, however positive responses were generally more frequent than negative ones. The only exceptions occured when subjects were asked to rate their confidence in final lens selection and testing accuracy. While the majority was again neutral, there was a notable bias towards the standard refractor's results over those obtained with the Burton I-TRAC Refractor.

BIBLIOGRAPHY

1. Rubin ML. Optics for Clinicians, 2nd Edition. Gainsville:Triad,1974.

2. Graf LO, Weaver JC. A Clinical Comparison of Three Astigmatic Tests. Doctoral Thesis, Pacific University College of Optometry: Forest Grove,1987.

3. Instruction Manual for AO Ultramatic Rx Master Phoroptor. American Optical:Buffalo,1976.

4. Thurston MO, Gundlach GF, Wood DE. Design of the Electronic Refractor. In a personal communication with DE Wood. RH Burton:Grove City,1984.

5. Operating Instructions for the I-TRAC Electronic Refractor. RH Burton;Grove City,undated.

6. Roggenkamp JR, et al. The IVEX refraction system: a clinical comparison. J Am Optom Assoc 1985 Jul;56(7):532-6.

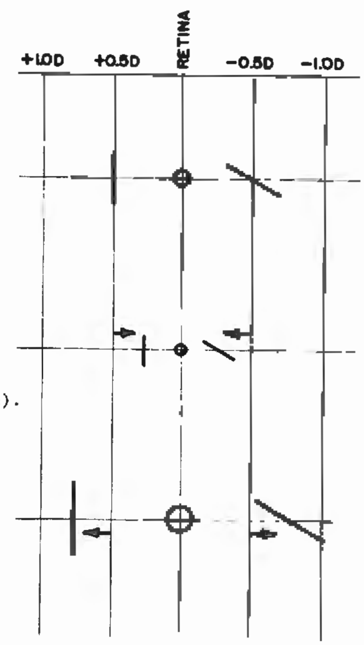
FIGURE 1

Illustration of astigmatic interval changes
created with the cross cylinder lens.

With an eye that has an uncorrected cylindrical refractive error of + 1.00 D (the separation between focal lines is 1.0 D), use appropriate sphere to shift Sturm's interval so as to position the circle of least confusion on the retina.

POSITION 1
Place a 0.25 D cross cylinder (+ 0.25 - 0.50 x 90) in front of above eye: each line will be moved inward by 0.25 D; the total astig. error remaining is now only 0.5 D and the circle of least confusion shrinks (as does each line).

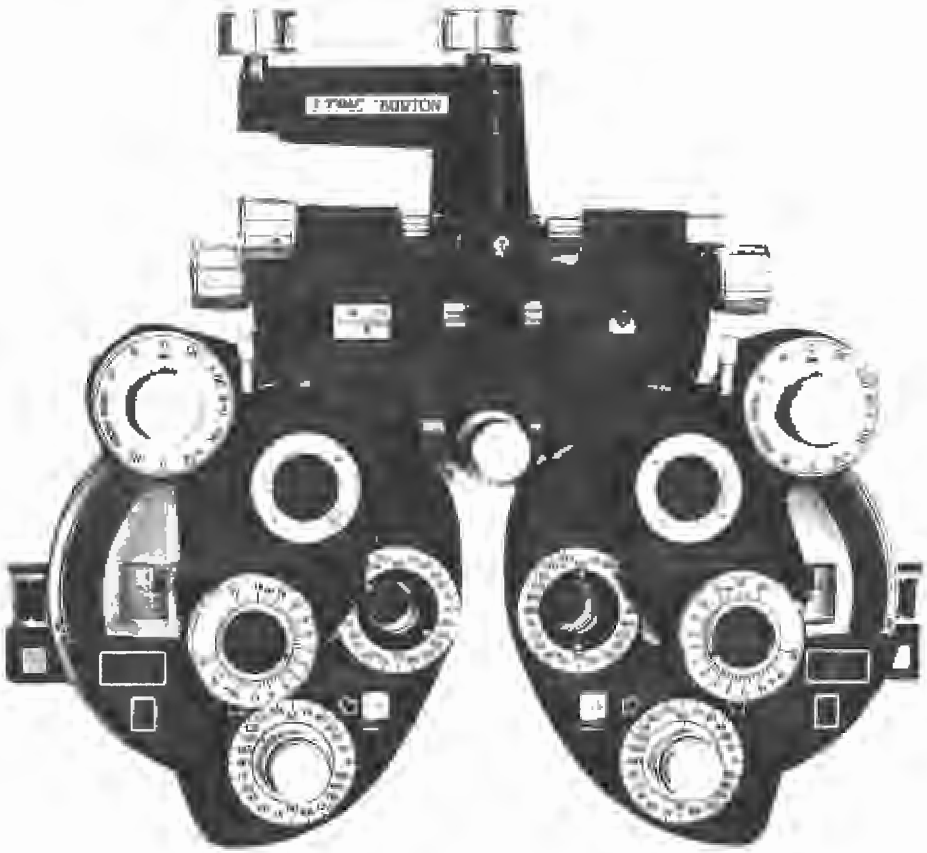
POSITION 2
Flip the above cross cylinder to (-0.25 + 0.50 x 90): each line moves outward. (Compared to the lines in Position 1, each line has been moved out by 0.50 D). The total astigmatism here is 1.5 D and the circle of least confusion enlarges (and the lines elongate).



(From Rubin ML. Optics for Clinicians, 2nd Edition. p.175)

FIGURE 2

Illustration of the Burton I-TRAC 8000 Refractor.

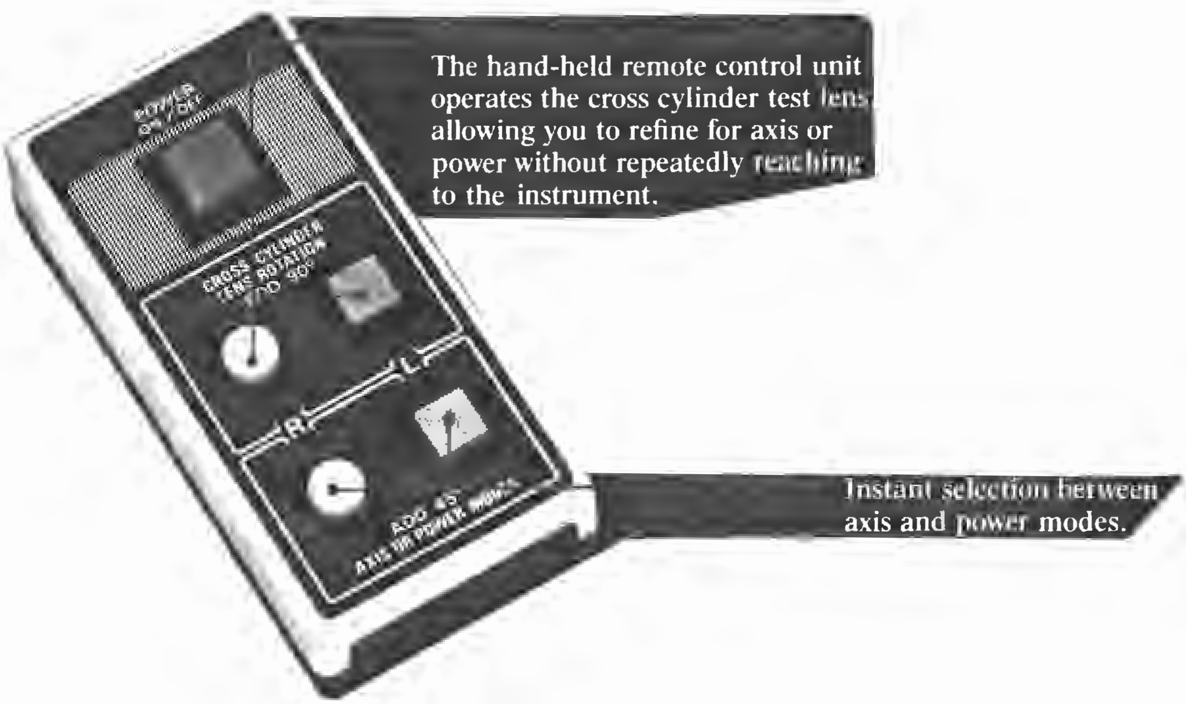


(Courtesy R.H. Burton Company, Grove City, Ohio)

FIGURE 3

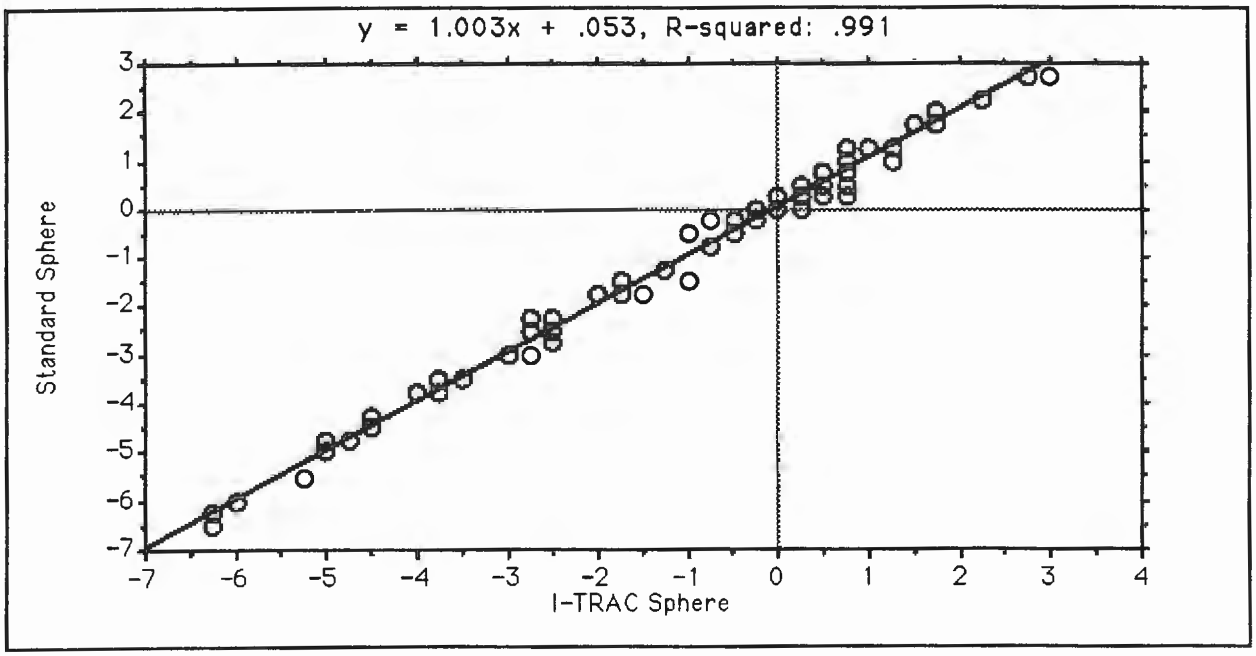
Illustration of the Burton I-TRAC 8000

remote control device.



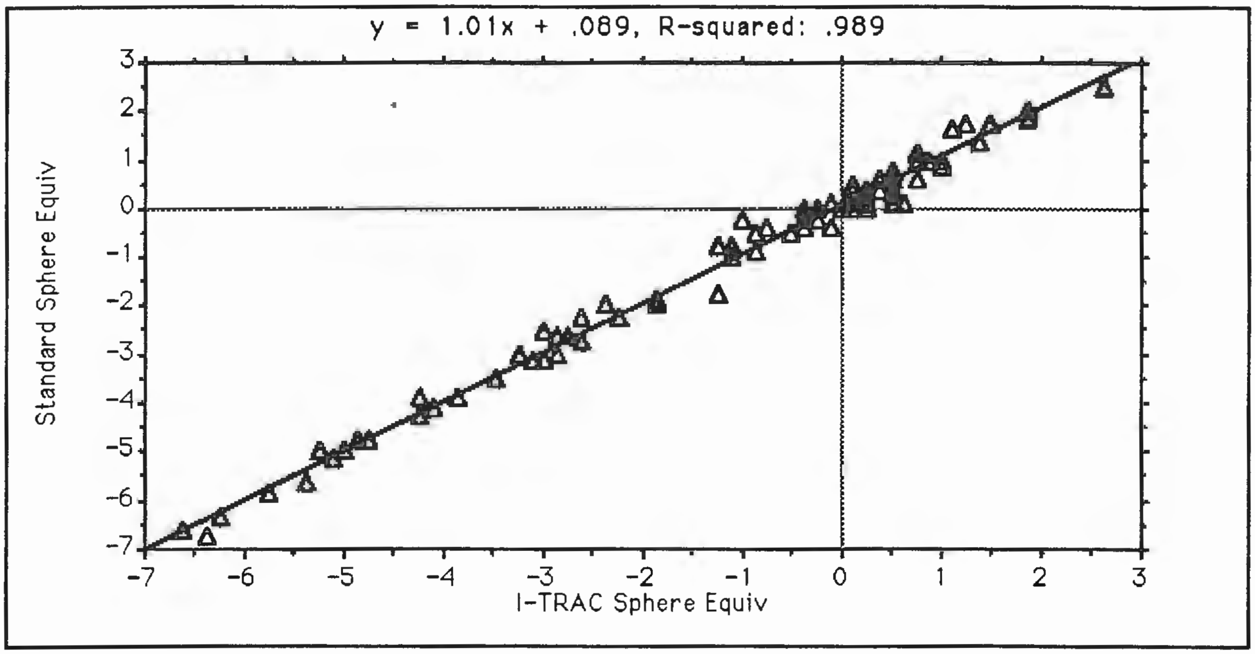
(Courtesy R.H. Burton Company, Grove City, Ohio)

FIGURE 4



Scatterplot of I-TRAC sphere power vs. Standard sphere power. Correlation coeficient 0.995. Number of points reduced because of overlapping powers between individuals.

FIGURE 5



Scattergram illustrating correlation between I-TRAC spherical equivalent power vs. Standard spherical equivalent power. R-squared equals 0.989 indicating a strong correlation between the two instruments.

FIGURE 6

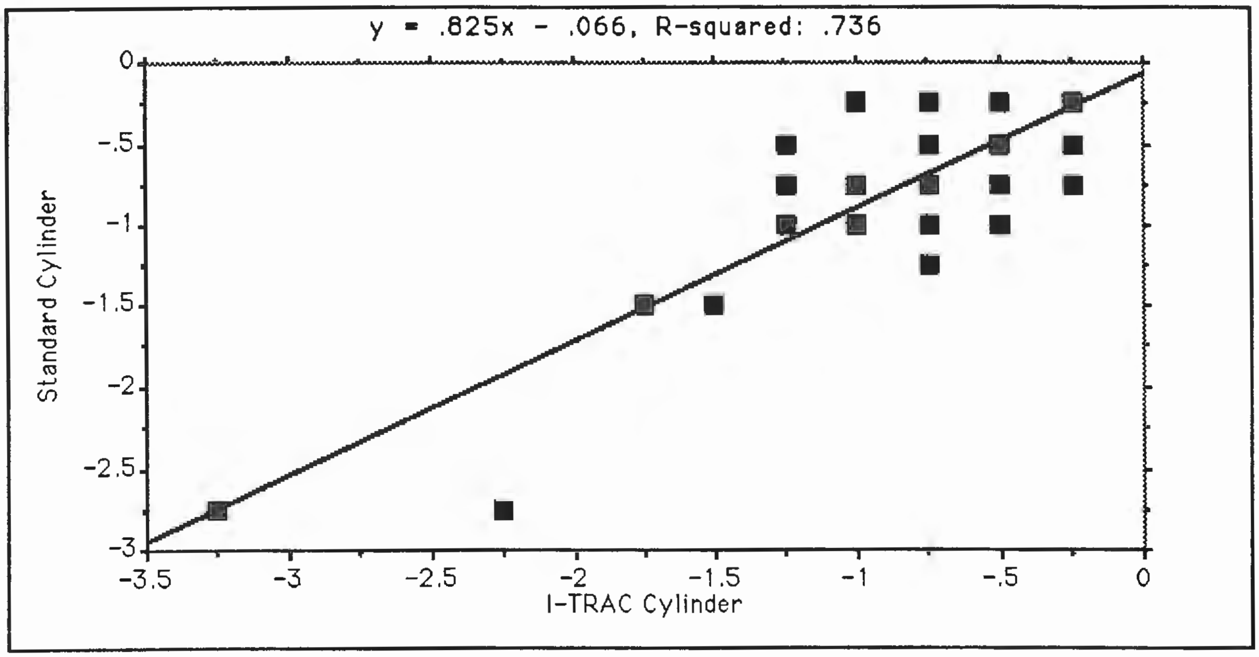


Figure 6 diagrams the correlation between the cylinder powers measured with the I-TRAC refractor vs. the Standard refractor. Correlation coefficient for these pairings equals 0.846. All data points are shown, but many overlap because of the small number of lens powers used.

FIGURE 7

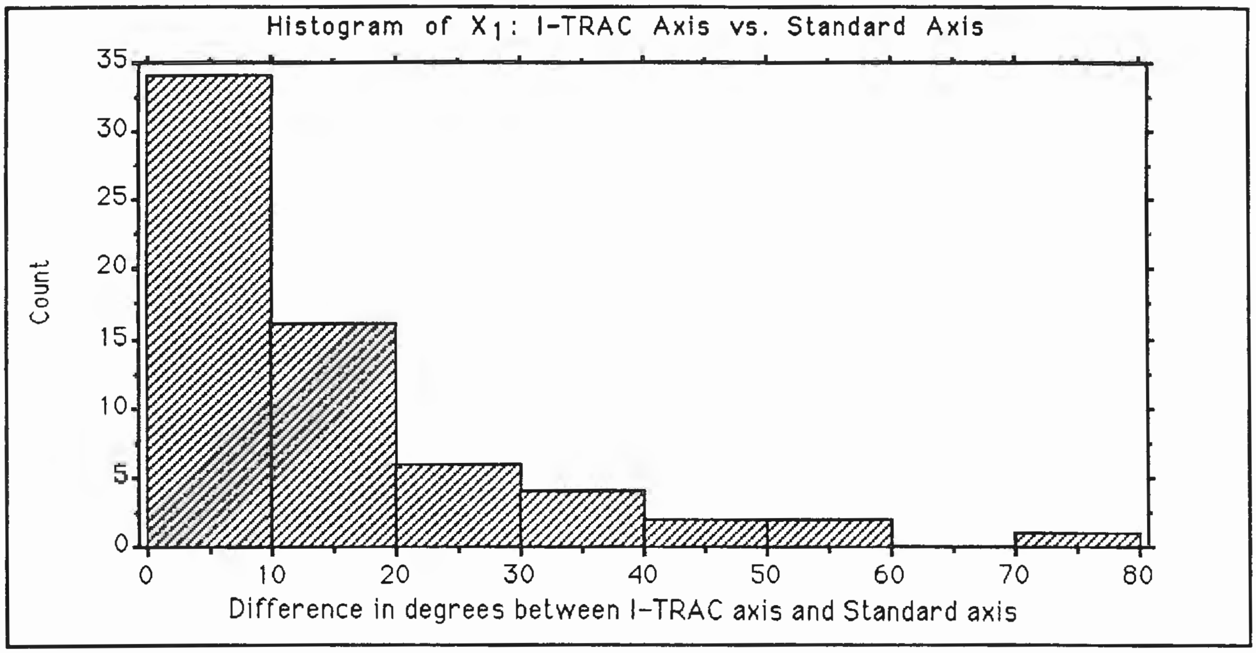


Figure 7 illustrates the frequency histogram of axis differences between the I-TRAC Refractor and the Ultramatic Rx Master Phoropter. Abscissa values represent the difference in degrees between correcting cylinder axes measured with each instrument. The ordinate scale is the relative frequency of each difference. The majority of axis differences (76.9%) were less than 20 degrees with mean cylinder power less than 0.62 diopters for either refracting instrument.

Table 1.

Summary of Mean Findings for 80 eyes.

	I-TRAC	Ultramatic	Difference
Mean Sphere	-0.981	-0.931	-0.05
Mean Cylinder	-1.282	-1.206	-0.076
Mean Sphere Equiv	-0.597	-0.531	-0.066
# Flips-Axis	8.90	8.10	0.80
# Flips-Power	7.05	6.82	0.225

APPENDIX A

List of advantages over other commercially available refractors that the Burton *I-TRAC* Electronic Refractor presents based on clinical patient evaluations.

1. MORE ACCURATE

- **a.** Discrete single degree cylinder axis changes can be easily made with the Burton ***I-TRAC*** Refractor. Other instruments require interpolation of an analog scale between degree marks of five degrees.
- **b.** Digital readout of cylinder axis can be easily seen to the single cylinder axis degree, even in a dark room which is customarily used for refracting. This minimizes errors of transposition which are possible with other refractors without discrete and lighted cylinder axis display.
- **c.** Illuminated dial face for reading the sphere and cylinder powers allows clear readout. Other instruments commonly used do not have illuminated dial faces and cannot be seen clearly in the customarily dark room used for patient refraction. Errors of transposition are minimized.
- **d.** The refractionist may also read the sphere or cylinder power clearly at any point during the refraction, allowing this information to be considered when lens powers are changed during the course of the refraction. Other refractors require a penlight or other source of light to be used during a refraction to clearly and accurately see these dials in a darkened room.
- **e.** The remote control enables the refractionist to select between the axis and power modes. The electronic indicator lights direct the refractionist to the next cylinder lens power or axis position which is to be tested for a patient. Currently available models require the refractionist to see small non-illuminated dots (white and red) on the face of the cylinder test lens. Limited lighting makes this task difficult with other refractors and at times causes the refractionist to make the wrong choice of lenses for the next patient comparison.
- **f.** The remote control to activate a cylinder test lens rotation minimizes the possibility for finger print smudges to be made on the test lens surface. Currently available refractors require that the change in position of the test lens be accomplished by finger or thumb activation of a mechanical flipping device located near the test lens surface. Smudges on a test lens will adversely limit the patient in making the correct choice between two similar appearing lenses when the refractionist asks the patient to do so.
- **g.** The rapid rotation of the cylinder test lens allows the patient to constantly view the test letter target while two lens power positions are presented to the patient. Currently available models require that the cylinder test lens be "flipped" which causes the test letter target to momentarily disappear. This loss of attention and view of the test target makes the comparison more difficult for the patient. Some patients experience uncertainty about which target looked best and, in fact, make the wrong decision. Constantly viewing the test letter target while the cylinder test lens power is changed is an advantage to patients in making the correct decision.
- **h.** Illuminated devices to measure the vertex distance of the patient from the front (refractionist side) of the ***I-TRAC*** aids in accurately assessing vertex distance (the distance from the back lens surfaces to the front of the patient's cornea). Other commonly used refractors do not have illuminated devices to verify this distance and consequently the measurement is either not made or made poorly. For patients with significant refractive error (i.e., greater than 8.00 D of myopia or hyperopia), an error of one millimeter in measured vertex distance will cause the refractive prescription to be inaccurate.

2. MORE EFFICIENT

- **a.** Because the indicator lights direct the refractionist which way to turn the test lens dial, (clockwise or counterclockwise) for subsequent test choices to be presented to the patient, the loss of non-productive lens movements is minimized. Other refractors require the refractionist to see small non-illuminated dots on the surface of the test lens surface, to interpret the meaning of this position, and then to move the cylinder test lens to its new position for subsequent choices. The use of an illuminated indicator lights on the ***I-TRAC*** refractor clearly tells the refractionist which way to turn the cylinder power and axis control knobs and no interpretation is needed.
- **b.** The refractionist can initiate the cylinder test lens position changes through a remote control. Other refractors require the examiner to initiate the cylinder test lens position changes through a mechanical device on the face of the refractor. In the case of the Burton ***I-TRAC*** refractor, these changes may be initiated with the refractionist seated comfortably with the arms down. For each lens change with the other refractors, the arms must be raised over the level of the refractionist's shoulder. A typical refraction would require twelve to fifteen such arm movements per eye or twenty-four to thirty per patient. This arm moving activity may be repeated on fifteen patients during a typical day and is most tiring.
- **c.** The patient can more quickly make the decision which is best between two cylinder test lens choices when the lens is rapidly rotated as compared to when the lens is "flipped" as it is in traditional refractors. Since the target the patient is viewing is constantly visible, the patient has more certainty in making the choice, and, consequently, makes it without asking for an inefficient repeat of the choices.
- **d.** The cylinder test lens does not require engagement into mechanical detents with the ***I-TRAC*** refractor. Once the cylinder test lens is rotated before the patient, it is ready for testing. Other refractors require an additional step of rotating the cylinder test lens into the appropriate engaged position between axis and power modes.

3. MORE CONVENIENT

- **a.** Dials for sphere, cylinder, and axis numbers are easily visible without requiring the refractionist to assume an unnatural posture or relight the room. Currently available refractors without lighted displays do not allow this convenience.
- **b.** Vertex distance measuring device is both lighted and visible from the front by the refractionist. Other models require the refractionist to move to the side to view a vertex scale and externally light the eye and scale.
- **c.** Since the sphere, cylinder, and axis numbers are visible, even in a darkened room, the refractionist does not have to repeatedly turn the room or instrument stand lights on and off during the refraction to see the dials.

APPENDIX B

SUBJECT QUESTIONNAIRE

PLEASE TAKE A MOMENT TO FILL OUT THIS QUESTIONNAIRE
REGARDING TODAY'S TESTING PROCEDURE

CIRCLE THE MOST APPROPRIATE RESPONSE TO THE FOLLOWING STATEMENTS -

1. THE ASTIGMATISM TEST THROUGH THE "ELECTRONIC" INSTRUMENT SEEMED -

   (MUCH EASIER   EASIER   NO DIFFERENT   HARDER   VERY MUCH HARDER)

   THAN THROUGH THE "STANDARD" INSTRUMENT.

2. BEING ABLE TO SEE THE TARGET AT ALL TIMES DURING THE ASTIGMATISM TEST WITH THE "ELECTRONIC" INSTRUMENT MADE THE TEST -

   (VERY EASY   EASY   NO DIFFERENCE   DIFFICULT   VERY DIFFICULT).

3. MY CONFIDENCE IN THE FINAL LENS SELECTION WITH THE "ELECTRONIC" INSTRUMENT WAS -

   (MUCH GREATER   GREATER   THE SAME   LOWER   MUCH LOWER)

   COMPARED TO THE "STANDARD" INSTRUMENT.

4. IT SEEMED TO ME THAT THE <u>MOST ACCURATE</u> TEST WAS WITH THE -

   (ELECTRONIC)   (STANDARD)   (NO DIFFERENCE)   INSTRUMENT.

5. IT SEEMED TO ME THAT THE <u>FASTEST</u> TESTING WAS DONE WITH THE -

   (ELECTRONIC)   (STANDARD)   (NO DIFFERENCE)   INSTRUMENT.

6. OVERALL, MY REACTION TO THE "ELECTRONIC" INSTRUMENT WAS -

   (VERY POSITIVE   POSITIVE   NEUTRAL   NEGATIVE   VERY NEGATIVE).

7. GIVEN A CHOICE OF INSTRUMENTS TO BE EXAMINED WITH, I WOULD PREFER

   THE -   (ELECTRONIC)   (STANDARD)   (NO PREFERENCE)   ONE.

POSITIVE COMMENTS ____.

NEGATIVE COMMENTS ____.